

The Balzer Form Relieving Tool.

Coming from a non-mechanical engineering background I found the concept of the Eureka [1] form tool reliever fascinating. One day I looked it up on YouTube and beside a nice video [2] showing all of the actions, there was also one modified to relieve hobs 'Charles Lessig's Hob Reliever Eureka Balzer Gear Cutting' [3], this introduced the word Balzer which I then investigated via Google ending up with a patent [4] dating back to 1895 for a most interesting tool.

Stephen M Balzer's device is exceedingly interesting relying on a set of 3 LOGICAL gears to emulate the ratchet driven motion in the Eureka. I call them LOGICAL gears as if made physically as single gears the system would lock up, but if they are built up in layers they end up making a '2 speed automatic self changing gear box'.

3 LOGICAL gears expand into a collection of 4 full gears and 2 half gears.

With this configuration the output will pause for half a revolution of the input shaft and then advance by $1/x$ th of a revolution on the completion of the input shafts revolution, x depends on the gear ratios. With suitable gearing x can be made equal to 12 as per the Eureka. The patent has gears of 60 & 52 teeth and will relieve a 15 tooth cutter.

Balzer Gear Calculations

To produce this magic there are very specific gear ratios involved

let N = the number of output steps required

let D = number of teeth fed per step

The output gear and the larger stationary gear have

$$N * D \text{ teeth}$$

whilst the smaller stationary gear has

$$(N * D) - (2 * D) \text{ teeth}$$

The following is my interpretation of the patent.

The gears in question are :--

1. A stationary sungear (19 in the patent drawing) with 2 sets of teeth in my proof of concept 24 & 20 teeth, this is built in 2 layers with 2 half gears with 12 & 10 teeth.
2. The output sungear (17 in the patent drawing) with 24 teeth. This is the same size as the larger stationary gear.
3. The planet gear (25 in the patent drawing), which is driven around its orbit at a constant rate, is the input gear. This is built with 3 layers with each layer having the same number of teeth 19, all aligned. This gear meshes with ALL layers of BOTH sunwheels. I chose a prime number of teeth for this to give a roving tooth to equalise the wear on it due to the alternating acceleration and deceleration cycles.

The end teeth on the half gears will require a bit of help with a file due to the misalignment during acceleration and deceleration phase.

The Steady arm, similar in function to the Eureka's Anchor Plate, lines up with the join between the gear halves.

For my initial dabbling I chose $N = 12$ and $D = 2$

giving 24 and 20 teeth respectively.

Initial models were 3D Printed as I haven't the facilities at home to do in metal.

The proof of concept was built with 2.0" centers and the gear pairs were 24 & 19 pair @ 10.75 DP, with the 20 & 19 pair @ 9.75 DP.

My next move was to print a prototype which I did using 1.5" centers so the unit would fit the Myford 7 series lathes, the gear pairs were now 24 & 19 @ 14 1/3 DP and 20 & 19 @ 13.0 DP.

Currently I am working on the Metal prototype and looking to reduce the size of the gear teeth to model engineering sizes, the gear pairs are now 36 & 29 @ 21 2/3 DP and 30 & 29 @ 19 2/3 DP (using $N = 12$, $D = 3$).

To calculate the button details required to make the cutters and in my case to be able to draw them for 3D printing I wrote a calculator using the formulae as published by Derek Brown[5], this has been submitted to the website for downloading.

- 1 Eureka
 Model Engineer Feb & March 1987

 Reprinted in Model Engineer
 Centennial Celebration Collection 1997
 2 Workshop Devices

 Also in Ivan Laws book
 Gears and Gear Cutting pages 123..130
- 2 https://www.youtube.com/watch?v=U_kqi3dqr50
- 3 Charles Lessig's Hob Reliever Eureka Balzer Gear Cutting
 https://www.youtube.com/watch?v=kJ8kyC_bpHs
- 4 Balzer patent of 1895
 <http://www.google.com.na/patents/US535127>
- 5 D.A.G. Brown Gear Cutters -- A Fresh Look
 Engineering In Miniature October 1998

 Duplex In The Workshop Articles 37..44
 Model Engineer May 19 to Aug 25 1949

 Kozo Building The Climax pages 40..43